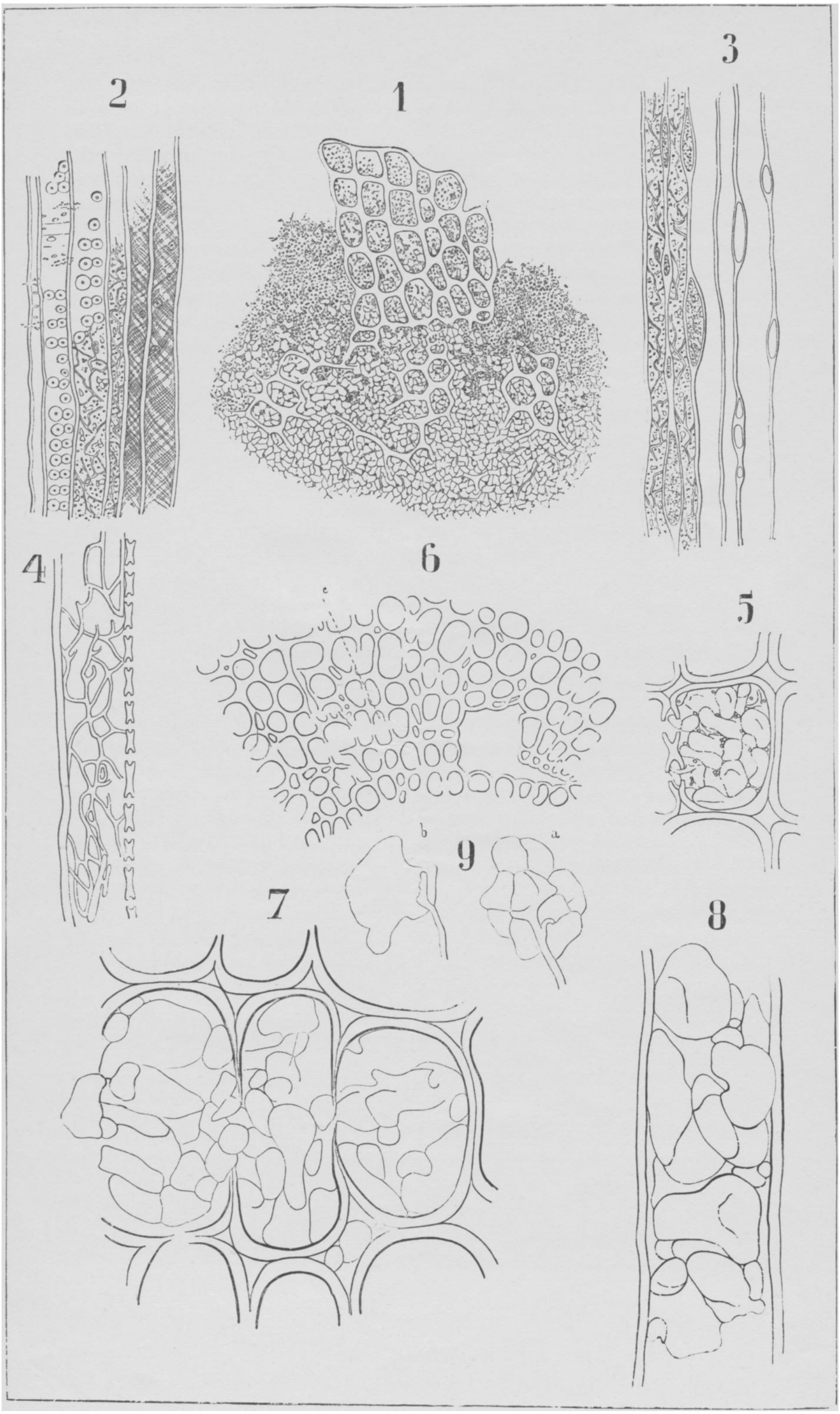

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Notes on Tuckahoe.

By Joseph Schrenk.

(Plate XLIII.)

For the bibliography, habitat, general appearance and chemical composition of tuckahoe I refer the reader to some editorial remarks appended to a note in Vol. ix., page 125, of the Bulletin, and to an elaborate paper on "Tuckahoe, or Indian Bread," by Professor J. Howard Gore, in the last Smithsonian Report (for 1881). In regard to the *structure* of this substance, however, I desire to discuss some important points that have not, as yet, received due attention.

The Bulletin (*l. c.*) says of tuckahoe: " * * * none, large or small, presents *any trace of plant structure.*" (Italics mine.) In the Smithsonian Report, page 695, we find the following passage: "There is not noticeable any membranous division between this bark [*i. e.*, of tuckahoe] and the substance within, *neither does the one merge into the other*, but there is a marked distinction between them. Within we find a compact white mass *without any apparent structure, either vascular or granular.*" (Italics mine.)

A piece of tuckahoe about $8^{cm.}$ in diameter, which I have closely examined, and which, in most particulars, answers the general description of the authors, has, on its rather smooth surface, numerous woody, fibrous, narrow shreds (from 2 to $5^{mm.}$ wide), which run longitudinally along the surface, somewhat like the strips on the trunk of the shag-bark hickory. They are firmly attached to the surface of the tuckahoe, above which they project only about $5^{mm.}$ or even less. A very thin cross-section through one of these shreds, together with a small portion of the adjoining surface, shows that the shred consists of coniferous wood-tissue, which is continued for a short distance into the body of the tuckahoe, below the general level of its surface. Fig. 1 of the accompanying plate, which represents such a cross-section, shows that there is no distinct boundary line between the woody tissue and the inner, white substance, but that the one merges into the other. The cells on the inner, centripetal side, are found in all stages of disintegration ; some have small openings in one or several of their side walls, others have lost one or several of their walls entirely, while still others have left no other traces of their existence than isolated, triangular columns, each marking the spot at which three contiguous cells have formerly met. These characteristic cell-remains (in Fig. 1 near the lower margin) are sometimes found quite a distance from the circumference, imbedded in the mass of tuckahoe. I detected them by using indol and sulphuric acid, that most beautiful reagent for lignin.*

* M. Niggl, Das Indol ein Reagenz auf verholzte Zellmembranen. *Flora*, 1881, p. 545 and p. 561.

Another specimen, about $6^{cm.}$ in diameter, has no shreds on its rough, much wrinkled surface, but has a cylindrical stick, $7^{mm.}$ in diameter, running centrally through its white mass, in the manner described by the above-mentioned authors, who consider such sticks as the remaining portions of the roots from which the tuckahoe is formed. No cellular tissue could be detected on or near the surface of this specimen; but sections from superficial portions of the central, cylindrical root and the contiguous white mass of tuckahoe displayed the very same gradual merging of the cellular tissue of the woody root into the mass of tuckahoe as described above, this time, of course, in reversed, centrifugal order.

The various stages of disintegration can also be seen in the interior portions of the root itself, for there are many places at which groups of cells, greatly varying in extent, have been partly or entirely destroyed, and replaced by the mass of tuckahoe. (Fig. 6, especially in the lower right-hand corner; also Fig. 7, three cells from *c*, Fig. 6, greatly enlarged.)

These observations seem to prove that tuckahoe does present traces of plant-structure, and also that there is a merging of the cellular tissue of the coniferous root into the mass of tuckahoe; and it is the structure of this latter substance itself that next attracts our attention.

From the above quotations it appears that this mass is thought to be compact and without any structure, either vascular or granular. The microscopical examinations recorded in the Smithsonian Report (pages 698 and 699) do not throw any light on this question; they seem to have been made with the one end in view of proving the fungoid nature of tuckahoe. I find that any section of this mass demonstrates that it consists of countless, minute, white, granular bodies of varying size and most irregular shape. All these granules have rounded outlines, but some are globular, others oblong, either stout or slender, and most of them have short branches, rounded excrescences or tubercles, which give them a very odd appearance. Not only the mass of tuckahoe proper is formed of these grains, but they are found crowding the cavities of the wood-cells described above and figured in the plate. (See Figs. 1, 5, 7 and 8.)

Perhaps it was these bodies on which the following description was based (Smithsonian Report, page 698): "The body of the fungus [*i. e.*, tuckahoe] is composed of short irregularly-jointed threads of mycelium, somewhat tuberculated, which swell considerably on heating with water." That these grains are not mycelium is evident from their very appearance, and still more so from their chemical composition. Potassium hydrate easily dissolves them, while the real mycelium, to be spoken of hereafter, remains nearly unchanged. They are also soluble in cuprammonia, causing a very copious precipitate of what I suppose to be pectate of copper. These characteristic pectin reactions* seem to leave no doubt that these granules constitute the bulk of *pectose* of which, according to all chemical authori-

* Kabsch, in Poulsen's Bot. Micro-Chemistry, translated by Prof. Wm. Trelease (S. E. Cassino, 1883), a book that cannot be too highly recommended to all students of histology.

ties, tuckahoe contains so large a percentage (from 64 per cent., R. T. Brown, to 78.4 per cent., Department of Agriculture.)

Quite distinct from these pectin bodies or grains—as I shall call them hereafter—are the *hyphæ* of some species of fungus that are found in tuckahoe. In the specimens examined, the hyphæ form a dense mycelium at and near the surface (Figs. 1, 2, 3 and 4), and also at all places where the white mass of tuckahoe shows the smallest fissures or cracks. Wherever the mass of pectin granules is compact and uninterrupted the hyphæ are either not seen at all or only very sparingly; nor could I detect any within the tissue of the central root (Figs. 6, 7 and 8). The wood-cells of the outer "bark," however, contain the hyphæ in great abundance, some, especially those nearest the surface (Figs. 1 and 4), to the exclusion of the pectose grains. The farther we proceed toward the centre, the more we find the pectin grains preponderate, until the hyphæ disappear nearly altogether. The same conditions can be observed in the interior, where each of the numerous cracks forms a sort of bed or channel for the mycelium, which sends its hyphæ right and left into the mass of granules.

Sometimes we detect the end of a hypha attached to one of the grains, either superficially (Fig. 9*a*), or entering it (Fig. 9*b*), but I have not been able to find any spores or organs of fructification.

It seems to me that too much stress has been laid on the occurrence of a fungus in tuckahoe, and that no attention has been paid to the essential difference in the substance of the fungus (fungus cellulose), and of the granular bodies (pectose). This neglect accounts for the inconsistencies contained in the latest hypothesis (Smithsonian Report pp. 695 and 697) attempting to explain the formation of tuckahoe: "These spores [found in tuckahoe] have the property of converting the woody fibre of the root into their own substance;" and, "It [*i.e.*, tuckahoe] gradually grows in this manner, appropriating the bark of the root for its own covering, until it becomes too large, during which process it forms a bark of its own, as already described." If the "spores" (*pars pro toto*, I presume) did transform the root into their own substance, we should not find *pectose* in so large a proportion, and the "bark" of the tuckahoe is nothing distinct in itself, but simply a very dense layer of mycelium either with or without a zone of peripheral cells of the tree-root within which the tuckahoe has been formed.

While studying this subject I could not help comparing the formation of tuckahoe with that secretion of the various resins and gums which is known as resinosis and gummosis.* The gums in particular present many chemical and structural similarities to tuckahoe. They contain great quantities of pectose,† and many chemists think that pectose is, in fact, nothing but metaarabin.‡ Mohl,§ Wigand,‖

*A. B. Frank, Die Krankheiten der Pflanzen, p. 75 and p. 85.

†Husemann, Pflanzenstoffe, Vol. i. (1882), p. 168.

‡W. Behrens, Hilfsbuch mikrosk. Untersuchungen (1883), p. 315.

§ *Bot. Zeitung* (1857), p. 33.

‖ Pringsheim's *Jahrb.*, Vol. iii., p. 115.

Karsten,* Frank‡ and Hofmeister§ have shown that the cell-walls within which gum is deposited disintegrate during the process of secretion, thus furnishing material for the latter. But both Hofmeister and Frank think that the gum begins to be formed in the cells before their disintegration commences, otherwise the large amount of the product could not be explained. Frank‖ gives a figure of a transverse section through a branch of a cherry-tree affected with gummosis, which in several respects very much resembles Fig. 6 of our plate. The same author has another figure¶ of a whole branch, a considerable portion of which has been changed into the gummous substance, and which could very well be compared to Fig. 1 of the plates in the Smithsonian Report representing a root encircled with a mass of tuckahoe.

Gummosis (and, to a certain extent, resinosis) is thought to be a process of degeneration accompanying the gradual cessation of the vital functions of some portion of a plant. An accumulation of plastic material takes place in the affected parts, and these are gradually absorbed and finally entirely destroyed. The causes of this process are chiefly mechanical injuries, *e.g.*, the breaking off of branches, the tearing off or bruising of the bark, etc.; but various other causes that tend to diminish or destroy the vital energy of some organ or of the entire plant may produce the same effect.

I have somewhat digressed from my subject, because it is my opinion that a close comparison of the nature and origin of the gums with those of tuckahoe will reveal many analogies which might entitle us to call the pathological process of which tuckahoe most likely is the result, *pectosis*. In that case the views of Rev. M. J. Berkeley and other mycologists (see BULLETIN, *l. c.*) would no longer be mere conjectures. It is not even necessary to assume with Currey and Keller (*l.c.*) that the fungus found in tuckahoe is the cause of its formation. As this fungus has not yet been proved to be *parasitic* on or in the living root-cells, while we have seen that it grows on the pectin granules, we might, with good reason, consider it a *saprophyte*, like hosts of its kind that thrive on disorganizing vegetable or animal substances. However, it remains very much to be desired that some competent mycologist should take this fungus in hand and throw full light upon its life-history, thereby at the same time solving the "puzzle" called tuckahoe.

EXPLANATION OF PLATE XLIII.—Fig. 1. Transverse section from the surface or "bark" of tuckahoe, magnified x 140. The large cells and cell-fragments belong to the projecting shreds of woody fibres, the small circles and corresponding parallel lines represent the hyphæ (transversely and longitudinally); the larger rounded bodies are pectin granules. Fig. 2. Radial section from the same part as Fig. 1, x 140. The cells show the characteristic bordered pits of coniferous wood, also the striation of the disintegrating walls; the edges are not so sharply defined as repre-

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* *Bot. Zeitung*, 1857, p. 319.

‡ Pringsheim's *Jahrb.*, Vol. v., p. 25.

§ Pflanzenzelle, p. 234.

‖ Die Krankheiten der Pflanzen, p. 86.

¶ *Ibid.*, p. 90.

sented in the figure, but eroded and of unequal thickness, especially those on the right, toward the centre. Mycelium and pectin bodies as in Fig. 1. Fig. 3. Tangential section corresponding to Figs. 1 and 2, x 140. The ellipses indicate the former position of the absorbed medullary rays. Fig. 4. Tangential section of one of the outermost cells of Fig. 1., x 500, showing mycelium and bordered pits in cellwall. Fig. 5. One of the cells of Fig., 1 magnified x 300. Fig. 6. Cross-section from central root x 140. The large, irregular, empty space on the right, as well as all the cells, were filled with pectin granules, as shown in Fig 7, which represents the group of three cells at *c* in Fig. 6 magnified x 700. Fig. 8. Radial section of a similar cell x 700.—Somewhat higher powers than those given were used in drawing the hyphæ and pectin bodies of Figs. 1 to 5.

New North American Grasses.

By F. LAMSON SCRIBNER.

BOUTELOUA TRIFIDA, Thurber, Gram, Mex. Bound. Survey, ined. —Perennial, 6–15 in. high, tufted and geniculate at the base; leaves 2 in. or less long, very narrow and usually involute, strigose-scabrous above and more or less rigid; spikes 3 to 6, pectinately many-flowered .5–1 in. long, erect or slightly spreading on short hairy pedicels; spikelets (including setæ) 3–4 lines long; outer glumes unequal, the upper and larger one about 2 lines long, both smooth, unequally 2-toothed and short awned; flowering-glume, exclusive of awns, about 1 line long, smooth or sparsely pilose, especially near the margins above; pedicel of the sterile floret smooth, bearing three awns, which equal those of the flowering-glume.

Texas and New Mexico; G. R. Vasey. Mexico; Dr. E. Palmer, No. 1,355, 1880. Dr. Palmer's specimens are taller, slenderer and more leafy than those from Texas and New Mexico. The latter have the base of the culms densely clothed with inflated sheaths that are tipped with short mucro-like leaves; the upper leaf also is much reduced, frequently not over a line in length.

This species is closely allied to the next, but is readily distinguished by its nearly smooth flowering-glume and longer and more slender awns.

BOUTELOUA BURKII, *n. sp.*—Culms slender, tufted, 4-6 in. high, erect or geniculate below, smooth or finely glandular-pubescent; leaves divergent, short, the upper .5 in. or less long, narrow and involute, smooth or, with the sheaths, glandular-pubescent, often with a few scattered longer hairs; spikes 3–5, about .5 in. long, pectinately many-flowered, erect or ascending; spikelets, including setæ, a little over 2 lines long; outer glumes ovate, smooth, nearly equal, the upper about a line in length, both usually very short awned just below the unequally bifid tip; flowering-glume, exclusive of the three continuous and equal awns, less than a line long, pilose with stiff hairs on the back and margins below; pedicel of rudiment .5 line long, smooth, bearing three equal and minutely scabrous awns 2.5 lines long, which are more or less enlarged and flattened near the base.

Laredo, Texas; Mrs. Anna B. Nickles; communicated to me by Mr. Isaac Burk of Philadelphia, for whom the species is named. Sandy plains, Upper Concho, West Texas; J. Reverchon; =No. 3,440* Curtiss's Distribution North American Plants.